

## 5. Radiation Climatology

If the radiant flux which the Earth is receiving permanently from the sun is distributed over the whole earth surface, the result is an radiant flux density of  $342 \text{ Wm}^{-2}$  (one quarter of the solar constant) as average extraterrestrial radiation.

The long-term, globally averaged energy balance of the earth-atmosphere system is shown in Fig. 5.2. To maintain thermal equilibrium (i.e.: constant long term average temperature), the incoming solar radiation must be balanced on average by an equal amount of radiant energy leaving the atmosphere into space. This is achieved by the reflection of shortwave solar radiation by the surface and the atmosphere as well as by longwave (infrared) absorption and emission of radiation by the surface and atmospheric constituents. The dominant role of clouds in shortwave reflection and longwave emission is very obvious. On average, only 52 per cent of the incoming radiation reaches the surface and thus is available for conversion in solar energy devices.

Only 52 % of the extraterrestrial radiation reaches the earth's surface, i.e.  $178 \text{ Wm}^{-2}$ , this gives the mean global radiation.

Long term mean solar radiation:  $90 < G < 250 \text{ Wm}^{-2}$  (extremely influenced by mean local cloudiness)

From the global radiation budget, it can be concluded:

- total radiation reaching the ground is decreased.
- radiation is scattered off the sun direction
  - diffuse radiation: radiation reaching the ground from other directions than the sun's direction
  - direct radiation: radiation reaching the ground from the sun's direction (angle of  $\sim 0.5^\circ$ )

Approximately, it is:

$\sim 30\%$  of incoming radiation is reflected back into space (by atmosphere, clouds and surface),

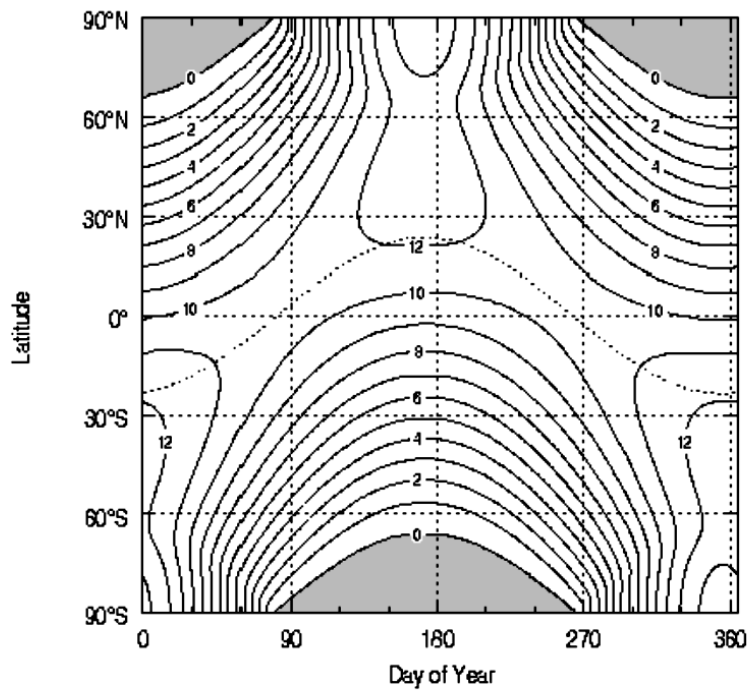
$\sim 20\%$  is absorbed in the atmosphere,

$\sim 50\%$  is absorbed by the earth surface.

Variability in time

- year-to-year, mostly non-deterministic
- seasonal (high latitudes!), variation of  $G_o$ , seasonal variation of cloud amount
- daily, highly deterministic

- short term fluctuations (clouds), highly stochastic and space
  - latitude
  - local climate (maritim, continental)
- long-term global mean:  $\sim 185 \text{ Wm}^{-2} = 5.8 \text{ GJm}^{-2}\text{a}^{-1}$   
 $= 1.6 \text{ MWh m}^{-2}\text{a}^{-1}$   
 $= 4.4 \text{ kWh m}^{-2}\text{d}^{-1}$
- seasonal variations: important for system layout!  
geographical variations: contrast between different latitudes!



**Fig. 5.1.** Average daily extraterrestrial radiation on a horizontal surface as function of season and latitude.

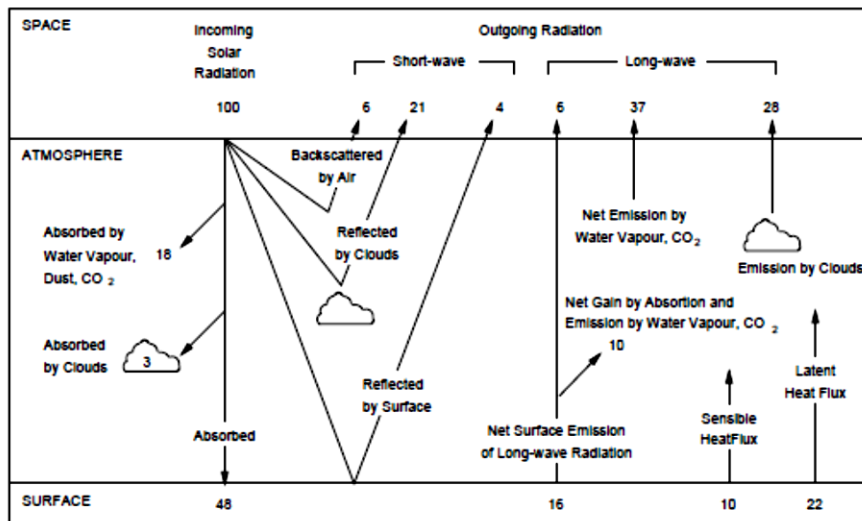


Fig. 5.2. Global mean energy budget of the earth-atmosphere system in percent of the mean solar input. 100 % =  $342 \text{ Wm}^{-2}$ .

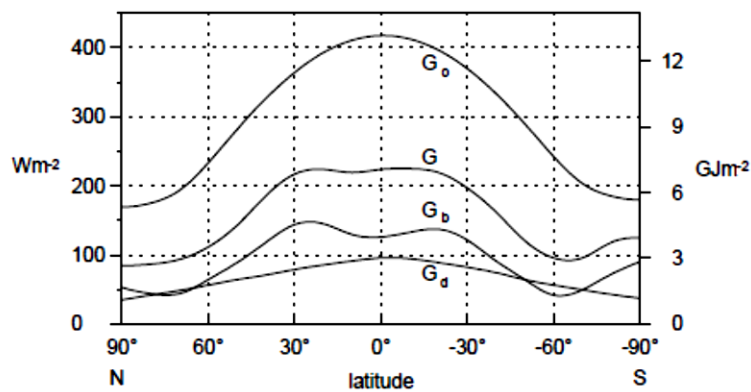


Fig. 5.3. Mean meridional profile of extraterrestrial radiation  $G_o$ , global radiation  $G$ , direct radiation  $G_b$  and diffuse radiation  $G_d$  on a horizontal surface. The scales are average irradiance (left, in  $\text{Wm}^{-2}$ ) and annual solar radiation (right, in  $\text{GJm}^{-2}$ ).

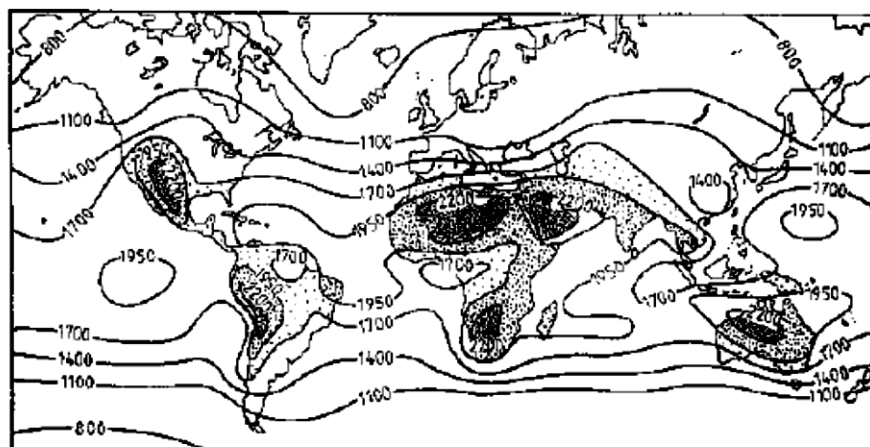


Fig. 5.4. Global distribution of annual average solar radiation (in  $\text{kWhm}^{-2}$ ).